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The perennialization of rivers through the construction of dams in the Brazilian northeastern semiarid region

La perenización de lo ríos a través de la construcción de charcas para combatir a la sequía en semi árido de región Nordeste brasileña

A perenização de rios pela construção de açudes para o combate à seca no semiárido nordestino

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Abstract

This article analyzes the perennialization of the Jaguaribe, Piranhas Açu and Capibaribe Brazil's rivers, from the construction of dams along their courses, due to the need to capture water to supply municipalities that suffer from the scarcity of this water resource in the Region East Northeast Atlantic Hydrographic from Brazil. The research has a bibliographical and qualitative approach. The results of the investigation showed that, although the construction of dams are seen as simple political practices, they cause environmental impacts such as the deforestation of riparian forests on the banks of these rivers. Thus, through reflections on the theme, it is understood that these works do not mean a definitive solution, but a guarantee of securing, with dignity, the inhabitants of the hydrographic region.

Keywords: Artificial perennialization. Intermittent rivers. Semiarid.

Resumen

El presente artículo analiza la perenización de los ríos Jaguaribe, Piranhas Açu y Capibaribe, a partir de la construcción de charcas a lo largo de sus cursos, en consecuencia de la necesidad de captación del agua para abastecimiento de ciudades que sufren la escasez de ese recurso hídrico en

Región Hidrográfica Atlántico Nordeste Oriental. La investigación posee un abordaje de rango bibliográfico y cualitativo. Los resultados de la investigación mostraron que, aunque las construcciónes de charcas sean vistas como simples prácticas políticas, producen impactos medioambientales como la deforestación de bosques ciliares a orillas de eses ríos. De esa manera, a través de reflexiones sobre ese tema, se comprende que esas obras no significan solución definitiva, sin embargo la garantía de permanencia, con dignidad, de los moradores de región hidrográfica.

Palabras clave: Perenización artificial; Ríos intermitentes; Semiárido.

Resumo

O presente artigo analisa a perenização dos rios Jaguaribe, Piranhas Açu e Capibaribe, a partir da construção de açudes ao longo dos seus cursos, em decorrência da necessidade de captação de água para o abastecimento de municípios que sofrem com a escassez desse recurso hídrico na Região Hidrográfica Atlântico Nordeste Oriental. A pesquisa possui uma abordagem de cunho bibliográfica e qualitativa. Os resultados da investigação mostraram que, embora as construções de açudes sejam vistas como simples práticas políticas, provocam impactos ambientais como o desmatamento de matas ciliares às margens desses rios. Dessa forma, através de reflexões acerca do tema, compreende-se que essas obras não significam solução definitiva, mas a garantia de fixação, com dignidade, de moradores da região hidrográfica.
Palavras-chave: Perenização artificial. Rios intermitentes. Semiárido

Introduction

The Northeast region has four types of climates: Tropical Humid or Coastal, Tropical Semi-arid, Tropical and Equatorial Humid. For the object of study of this work, the semi-arid climate region, characterized by scarcity and rainfall irregularities, is analyzed. According to data from the National Institute of Meteorology (IMET, 2017), the rainfall in this region is less than 800 mm/year, average temperatures are around 27º C and the thermal amplitude is around 5º C. is 2000 mm, while the average rainfall in the Northeast is 1000 mm. The Brazilian semi-arid region has a high rate of evaporation and long periods of insolation, it is also on a crystalline geological structure, which makes it difficult to replenish the water table. This results in low hydrogeological potential, making it necessary to build dams to retain rainwater and, in certain cases, to perpetuate rivers. In this way, storing rainwater is considered of singular importance to meet the water needs of the

population of municipalities and localities that experience situations of inefficiency in supply. Then, the practice of building artificial reservoirs, which became a drought containment policy for the semi-arid region, called the "hydraulic system", began at the end of the 19th century and later became the area of action of the National Department of Works Against the Droughts - DNOCS (ASSUNÇÃO, LIVINGSTONE, 1988). In this context, the research, of bibliographic character and which follows principles of integrated analysis of the landscape, aims to reflect on the perennialization of the Jaguaribe, Piranhas Açu and Capibaribe rivers, located in the Northeast East Atlantic Hydrographic Region (RHANO-MMA, 2006), through the construction of dams along their beds.

The installation of these reservoirs has links with the regularization of flows and supply, as periods of drought can be extensive and cause inconvenience to the population. These artificial works are an alternative that maintains sertanejos on their lands, having facilitated access to water for their own consumption and for watering animals.

However, it is known that these practices cause significant socioeconomic and environmental impacts, considering that vast areas are flooded, entire human communities and herds of animals displaced, and vegetation cover suffocated. Such impacts must be previously foreseen in works execution projects, so that specific mitigating actions are established.

The study is based on authors such as: Assunção and Livingstone (1993), Rebouças (2003); Molinas (1996); documents such as Caderno RHANO (MMA, 2006); Federal Law No. 9,433/97, which regulates guidelines and norms referring to national policies in the water resources sector; and the National Water Agency (ANA, 2000).
The interest in research on the topic addressed arose during reflections related to the Hydrography curricular component of the undergraduate degree in Geography, setting up an opportune moment to expand knowledge about the peculiarities of Brazilian water resources, especially in the Northeast of the country. Therefore, it is

considered that it is a text that is relevant to stimulate new academic works that involve contextualized discussions with the theme.

Water law and granting of the right to use water resources

The evolution of the law on the use of water occurred from the moment that this resource became a source for various uses for humanity. Although the laws that touch this resource still have flaws, distortions and contradictions, over time these have become fundamental in the regularization of the democratic use of this resource. Thus, one of the first laws was Decree 24,643 of July 10, 1934, which specified the use of water in industry and in the production of electricity, due to the industrial process of the period. However, this decree dealt more closely with the quantity of water intended for use, not its quality.

The first act to discuss the management of water resources in Brazil took place in June 1992 at the United Nations Conference on the Environment, held in Rio de Janeiro. However, it was only in 1997 that the legislation showed greater applicability regarding the use of water in a rational, conscious way, for the benefit of all, both in quantity and in quality. This was evidenced through the National Water Resources Policy, sanctioned by Law 9,433/97[4].

Created in 1997, Law No. 9,433, better known as the Water Law [5], instituted the National Water Resources Policy (PNRH) and created the National Water Resources Management System (SINGREH), with the objective of protecting water sources candy. Its creation defines that the use of water should prioritize human consumption and the watering of animals, especially in situations of scarcity, as it is a resource that is increasingly limited. Thus, the Law proposes that this resource must be managed rationally, favoring future generations.

[4] Available at https://conteudojuridico.com.br/consulta/Artigos/52115/evolucao-historica-da-legislacao brasileira-sobre-o-uso-da-agua> consulted on 02 November 2020
[5] With the Magna Carta of 1946, it was evidenced in article 34 as goods of the union, lakes and any water currents in lands of its domain or that bathe more than one State.

In this Conception, each state brings a specific resolution on the use of water, and the Water Law guarantees the grant, which is the instrument of the Water Resources Policy intended to ensure the quantitative and qualitative control of water uses (Table 1).

Table 1- Normative laws of water resources of the states that make up RHANO.

States	Ceará	Rio Grande do Norte	Alagoas	Paraíba	Pernambuco
Law /nº	11.996/1992	6.908/196	6.126/1999	11.427/1997e 6.308/1996.	7.033/2001.e 11.427/1997.
Specifications	The Law created the secretary of Resources water that starts to regulate guidelines of water use in the state.	Provides for the State Policy of water resources and establishes the System Integrated Management of Water Resources (SIGER)	Through this Law it was created the secretary of water resources of state, normalizing the use of water.	The first calf the Water Agency, Irrigation and Sanitation from the State of Paraíba (AAGISA), the second offspring the state policy of water resource for regulation of the use of Water.	The first calf the Water Agency, Irrigation and Sanitation from the State of Paraíba (AAGISA), the second offspring the state policy of water resource for regulation of the use of Water.

Source: www.al.ce.gov.br, 2020; progestao.ana.gov.br 2020; www.semarh.al.gov.br 2020; www.aesa.pb.gov.br 2020; Paraiba.pb.gov.br 2020; legis.alepe.pe.gov.br 2020

According to ANA (2011), the granted user has the right of access to water from a river, natural lake or artificial reservoir, since it regulates its use in a given watershed (map 1).

Map 1- Domains and granting of water resources - demonstrative model (ANA)

Source: Ana-2013

The issuance of a grant must be requested by whoever wishes to make use of the resource, which is carried out by the state domain (basin committees and executing agencies), that is, any and all water resources established within regions belonging to a certain state of the federation. In the case of the union, they are the resources as a whole (which covers the territory of more than one state), being under the direct action of the ANA and national committees. (ANA, 2020)

The granting of groundwater must be issued by the state government or the Federal District, emphasizing that rivers that border other countries, even within the state, the granting body is the union.

Water scarcity in the Eastern Northeast Atlantic Hydrographic Region

It is known that the scarcity of water in this hydrographic region is highly critical, given the relevance of the dams for public supply in the states of Ceará, Rio

Grande do Norte, Pernambuco, Alagoas and Paraíba, which suffer from water deficit, with rains below the average of the Northeast itself and intense insolation, which influences the intermittent condition of rivers that bathe the semi-arid region of these federation units.

Within the RHANO, the municipalities of Irauçuba, in the state of Ceara, and Seridó, between Rio Grande do Norte and Paraíba, have the largest water deficits in the region, even evolving into desertification processes. A scenario of water stress is configured, which directly impacts the availability of water for human consumption, as is the case in the city of Irauçuba, supplied by the Jerimum reservoir. In order to solve this problem, in 2014, the pipeline that captures water in the Missi reservoir was inaugurated, located in the municipality of Miraíma, which has the capacity to retain 65,301,000 m³ of water (BRASIL, 2015).

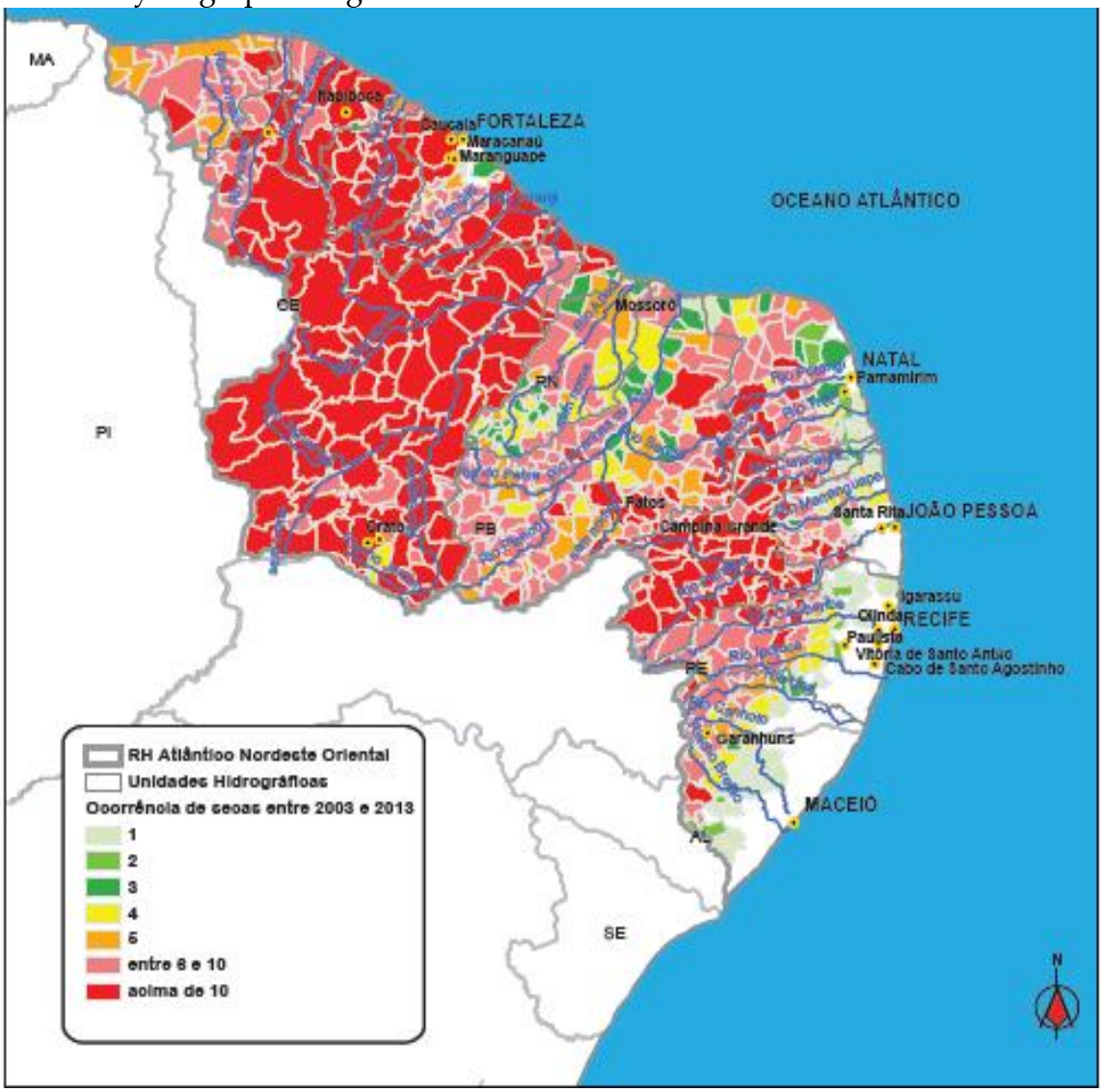
According to the Northeast Development Superintendence (SUDENE), which monitors water scarcity in the semi-arid region, the region formed by 24 municipalities bathed by the Seridó river basin, between the states of Paraíba and Rio Grande do Norte, is the one with the most suffers from drought at RHANO. Some reservoirs in Seridó, such as Dourado and Gargalheira, arrived in 2017 with critical levels of storage, unable to supply water to the population of the towns of Currais, Acari and around, where the hope of normalization was deposited in the event of rain.

The northeastern semi-arid region also has a low hydrogeological capacity because it presents a geological formation composed of crystalline rocks, which make infiltration/percolation difficult, inhibiting the formation of water table and the availability of groundwater. As a result, tubular wells are low-efficiency mechanisms or, in certain cases, totally inoperative in capturing water from the subsoil.

In addition, the salinity content of well water is high, which is attributed to the release of minerals that are found in the composition of this type of rock, and are released with weathering. This scenario amplifies actions aimed at the construction of dams to, in theory, provide access to water to improve quality. However, as the

evaporation rate is high - and when these reservoirs do not have a bottom outlet to renew the stored volume - the salinization process of these waters is triggered over time (REBOUÇAS, 2003; BRASIL, 2015).

Map 2 - Occurrences of droughts between 2003 and 2013 in the Eastern Northeast Atlantic Hydrographic Region.



Source: MMA (2015)

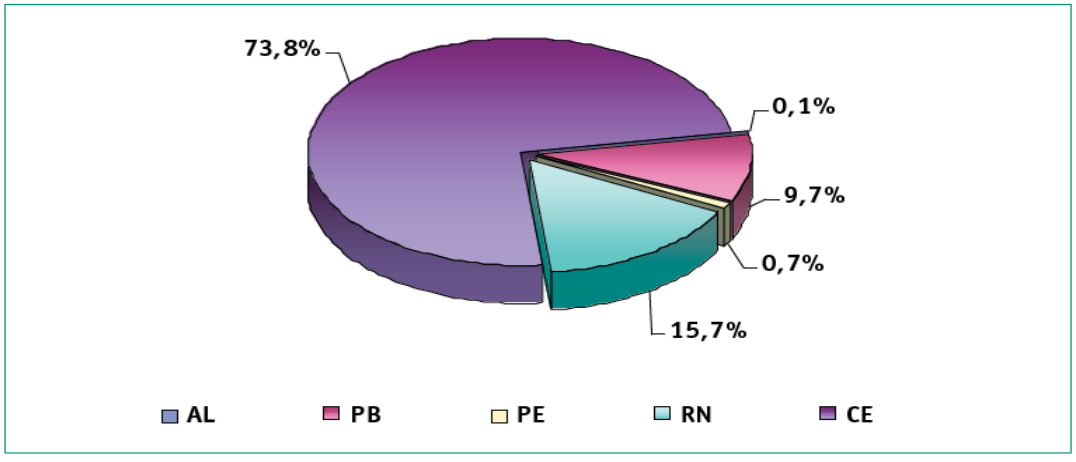
With the search for water striking in everyday life and in the popular imagination, the northeast of the semi-arid region in general is encouraged to change their perspective, starting to live with the drought in a harmonious way and no longer to end it. The construction of medium and large-sized reservoirs is seen as the way out for the regularization of river courses in order to supply urban and rural communities that suffer from water scarcity (map 2).

According to map 2, the State of Ceará represents the highest occurrence of droughts, which justifies the structured monitoring and management system dedicated to the water resources sector. In the Jaguaribe river basin, which bathes the state, there is a predominance of droughts, with more than 10 occurrences between 2003 and 2013, being the reason for greater investment by DNOCS in the construction of dams in the river bed (MOLINAS, 1996). ; BRAZIL, 2015).

In the upper and middle courses of the Piranhas-Açú and Capibaribe rivers, there are 6 to 10 droughts in a period of ten years, enhancing the perennialization of water flows in their drainage networks. In the lower course of the Jaguaribe, close to its mouth in the Atlantic Ocean, there is only one drought during the studied period. It is only on the northeastern coast near Maceió and Recife that there are lower rates of droughts during this period (BRASIL, 2015).

Historically, the dam has been a solution to mitigate the effects of droughts in the Brazilian semi-arid region, seen as a driver of improvements in the population's quality of life (Graph 1).

Graph 1- Public weirs built by DNOCS at RHNAO. Distribution capacity by state.



Source: DNOCS, 2005.

Graph 1 shows the percentage of water storage by state from the installation of dams built at RHANO until 2004. It can be seen that the states of Pernambuco and Alagoas have the lowest share in the amount of dams to supply the region , not

reaching 1%. Meanwhile, Ceará reaches more than 70% of its supply potential, with the presence of large reservoirs such as Orós and Castanhão (BRASIL 2015).

The dam is the hope of the northeast to remain confident in the face of drought situations in the sertão. The perseverance of the sertanejo in this search for alternatives to improve the condition of his life has the year 1890 as an important milestone, when the policy of construction of dams in the Northeast began. The Cedro public dam, built in the municipality of Quixadá in the State of Ceará, on the bed of the Sitiá River, symbolizes this moment. There are two aspects to this process: one is to alleviate the effects of the drought that devastates the Northeast during the dry season; and the other is the containment of large floods that occur in the wettest months (ASSUNÇÃO and LIVINGSTONE, 1988).

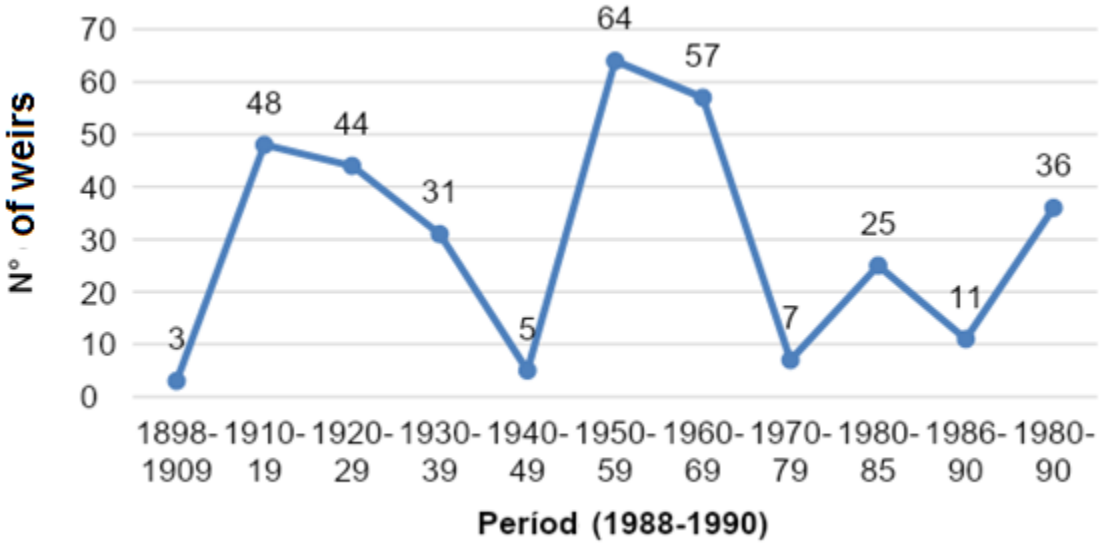
In 1945, the DNOCS began to implement measures to alleviate the criticality faced by the population of the northeastern sertão with the increase in the construction of dams throughout the region. Thus, this department developed measures for implementation in infrastructure for the integrated use of water resources. In fact, a report presented by Assunção and Livingstone (1988), analyzing the basic program of the DNOCS on the subject, was taken into consideration by authorities in the Northeast, mainly within the Superintendence of Development of the Northeast (SUDENE), but it does not seem to have had a permanent effect. why:

> Among the priority programs and projects for 1986-91 of the DNOCS, one can find those for the construction of 33 new dams with an estimated global capacity of 8.5 billion cubic meters, more than the total built in the previous 26 years, since 1960. In addition, these dams should be, on average, much larger than those built until then, above 257 million cubic meters. For reasons beyond the control of DNOCS, this plan could not be fully implemented. (ASSUNÇÃO; LIVINGSTONE, 1993, p. 429).

Graph 2 shows the number of dams built over the years from 1898 to 1990, which provided subsidies for water supply for the population of the semiarid region, as well as for the development of irrigated crops and livestock, through the

perennialization of intermittent rivers. It can be seen that the Graph also shows the number of dams built per decade, and between 1950 and 1959 it was the most productive period, reaching the figure of 64 dams completed. From 1970 to 1979 the works fell significantly, with only seven reservoirs being built. There is then an oscillation in the numbers of dams built by DNOCS.

Graph 2- Public Weirs Built by DNOCS [6]



Source: Asuncion; Livingstone.(1998), adapted by the authors(2020)

With the construction of these public dams, especially in the semi-arid region of the Brazilian Northeast, the storage of water during periods of higher rainfall is increased. Due to different characteristics found in the region, where there is no regular distribution of rainfall over the years, the dams favor survival in the northeastern sertão.

According to DNOCS (1988), resources destined to works against drought alternate according to the intensity and amplitude of the drought, with variations over the years in the periods between 1965-1988, especially from 1975 onwards. By the end of 1990, the agency had built 295 dams with a total capacity of 15.59 billion

[6] This is the official number reported in DNOCS (1991). The exact sum of this column would be 15,626.04, which represents a difference of only 0.2%. Sources: DNOCS, Dams in the Northeast of Brazil; DNOCS, Fortaleza, 1982a; DNOCS, Reports 1983-88 and DNOCS, DNOCS Basic Functions to Respond to Present and Future Challenges. Fortaleza, 1991. Mimeo.

cubic meters. Table 1 shows how much the construction of reservoirs is necessary to alleviate the situation of water scarcity at RHANO.

Adding all the water storage equipment present in the Brazilian Northeast, considering federal, state, municipal, private and cooperative public dams, we arrive at 70,000 reservoirs, making the semiarid region the region with the highest concentration of dams in the country (RIBEIRO 2010).

Table 2 - Evolution of Northeast reservoirs from October 2109 to January 2020

October 2019	%	January 2020	%
Maranhão	65,1	Maranhão	65,1
Ceará	16,8	Ceará	14,0
Piauí	48,4	Piauí	42,8
Bahia	41,4	Bahia	38,4
Rio Grande do Norte	26,4	Rio Grande do Norte	23,1
Paraíba	19,4	Paraíba	16,5
Pernambuco	19,4	Pernambuco	15,5
Total	**23,0**	**Total**	**19,6**

Source: Monitoring Bulletin of Reservoirs in Northeast Brazil v.14, n.20 out. 2019

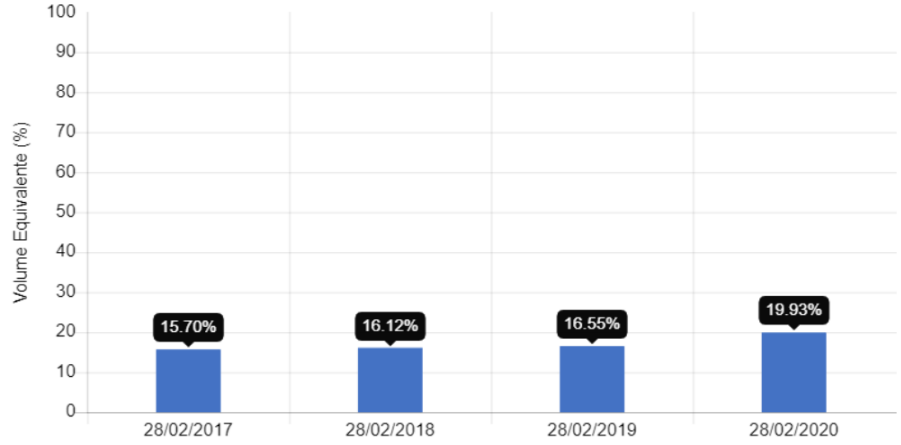
In Table 2, it can be seen that the State of Maranhão had the greatest prominence, followed by Piauí, while Ceará had the lowest number of reservoirs. The Northeast states as a whole in October 2019, presented a percentage of 23.0%. Making a comparison with the following year, which represents the equivalent reservoirs of January 2020, it is possible to see that Maranhão remained with the same percentage as in 2019, with Piauí still in second position. However, there was a decrease compared to 2019, in which Ceará continued to occupy the same position (BRASIL, 2015).

This decrease may indicate that a high rate of perennialization of river flows was reached through the construction of dams in the studied environment. In this way, it is understood that possibilities for the permanence of sertanejos in the countryside are expanded, with favorable conditions for living with the drought.

In this conception, it is understood the relevant importance that water reservoirs have in the scenario of drought through the perennialization of rivers,

although it is recognized that unfavorable impacts to the environment are also generated. Graph 3 represents the evolution of the northeast reservoirs from February 2017 to February 2020, with an annual growth in the reservoirs.

Graph 3 - Equivalent reservoirs in the Northeast (%)



Source: ANA (2020).

It is possible to see, in Graph 3, the evolution in the installation of reservoirs between the years 2017 and 2019, information that confirms how much these works are necessary in the coexistence of the population with the drought. The dams are able to store water for long periods of time, being multi-annual[7] and inter-annual[8] reservoirs, and their main purpose is to minimize the effects of drought, regulating the flow of rivers in the Brazilian semi-arid region. The perpetuation of intermittent rivers is remarkable at RHANO, enabling the expansion of water supply to the Northeastern population.

Perennialization of the Jaguaribe, Piranhas Açu and Capibaribe rivers

The droughts of 1825, 1827 and 1830, according to Rebouças (1996), would have stimulated the beginning of the process of construction of dams in the northeastern semi-arid region as a water storage strategy for human supply and for

[7] Capacity to store water for several consecutive years without drying the reservoir.
[8] Water storage capacity for one year with smaller reservoirs (with a volume of less than 10 hm^3).

watering animals. With the implementation of public policies aimed at combating droughts, this practice was consolidated in the region, especially in RHANO.

Social reflexes derived from droughts are striking in the sertão, where the hegemony of coroneis can be seen, exploring the sertanejo's weaknesses enhanced by the lack of water. This situation reaches the point of using dam practices as a political factor, which, combined with the concentration of land near perennial rivers by this agrarian elite, ends up disrespecting the right of the majority of the population to access water and land.

It is noteworthy that the Northeast has the second largest Brazilian population and concentrates the lowest levels of water resources, while the North of Brazil has the smallest population and has the largest reserve of water resources in Brazil. This shows how this resource is distributed unevenly in the country.

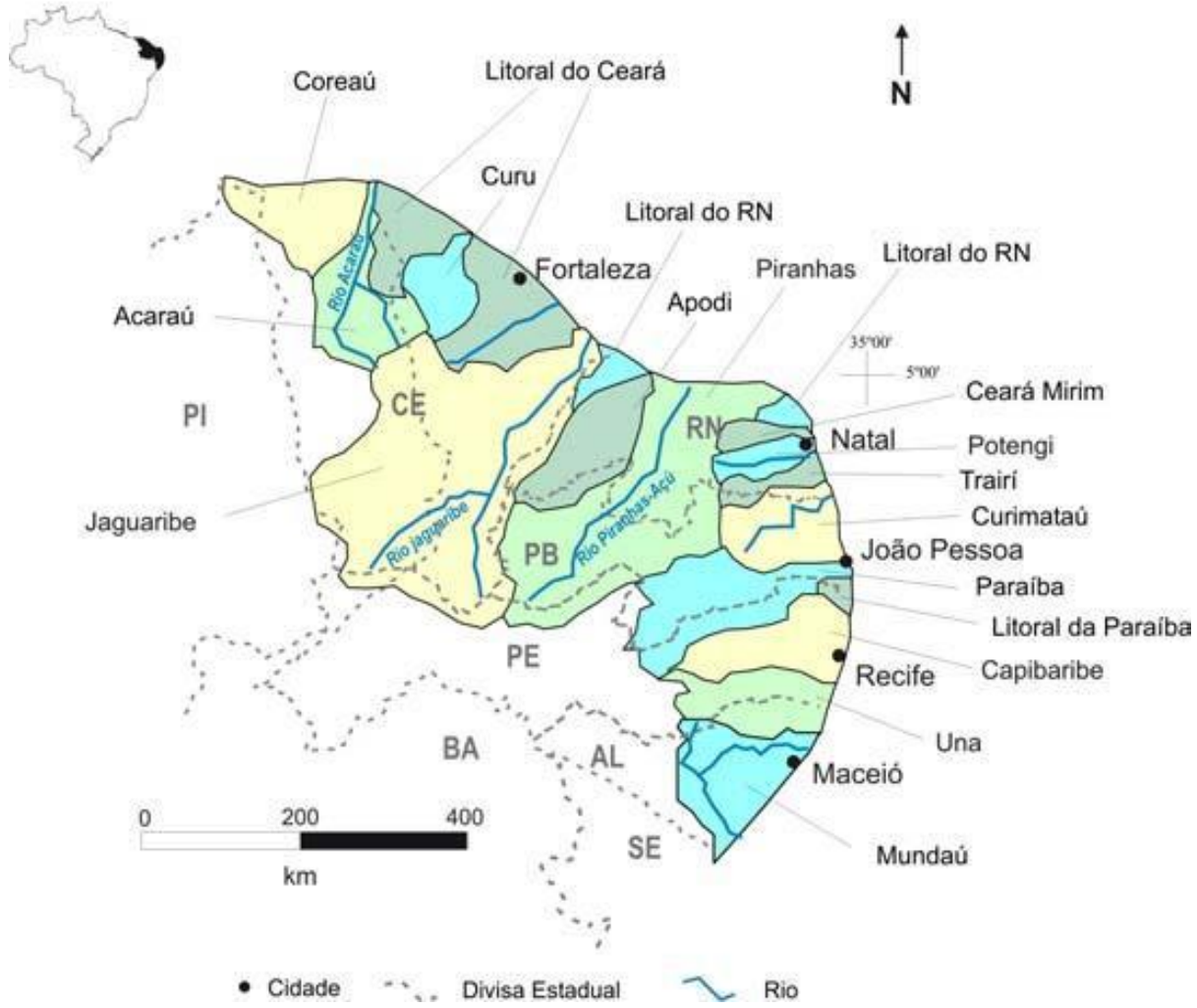
RHANO (figure 3) is located mostly in the drought polygon, where climatic characteristics such as intense insolation, high evaporation and low rainfall are common.

Data from the National Institute of Meteorology (INMET) indicate that the average annual precipitation in RHANO is 1,052 mm, below the national average, which is 1,761 mm. As a result, this hydrographic region has a high water deficit with prolonged periods of drought, hindering the development of municipalities located on the banks of rivers.

RHANO is divided into sub-regions with specific peculiarities, in order to facilitate the management and implementation of public policies. (map 3)

In map 3, it can be seen that the springs are concentrated in the interior of the hydrographic region, precisely where the water deficit is high. Some of these rivers were exclusively intermittent before the regularization of their flows and became strategic for the supply of some States.

Map 3- Subdivisions Hydrographic Region Northeast Atlantic East- RHANO- 2006



Source: Brasil das Águas (2006)

In this sense, the importance of artificial perennialization of these rivers is clear, in which the condition of intermittence is changed to that of constant flow of water in beds, helping to contain disaster situations linked to droughts in the semiarid region (OLIVEIRA, 2011). Between 2012 and 2017, one of the worst droughts in the Northeast occurred, with six years of rainfall below the annual average, aggravating the water deficit in RHNAO. In view of this, in many localities

the people obtained water by digging wells in the bed of dry seasonal rivers, increasing the demand for the construction of reservoirs.[9] .

The Jaguaribe River rises in the Serra da Joanina, in the municipality of Tauá, in the Caatinga region in the interior of Ceará and is the largest and most important river in the state. Its sub-basin drains an area of 75,670 km², is 610 km long and benefits 81 municipalities in Ceará. (map 3)

The Jaguaribe River extends on the border of the Ceará municipalities of Fortim and Aracati, receiving its tributaries (Salgado, Banabuiú, Cariús, Sangue, Palhano, Jucá, Conceição, Figueiredo and Quixeré rivers), perpetuated by the Orós and Castanhão reservoirs. On its way towards the Atlantic Ocean, the Jaguaribe passes through the cities of Aracati, Tauá, Fortim, Arneiroz, Iguatu and Jaguaruana.

The Orós reservoir, opened in 1961, is located on the Jaguaribe riverbed, 450 km from Fortaleza in the south center of Ceará and has a storage capacity of 2.1 million/m³. The public dam Padre Cicero, better known as Castanhão, is located in the middle course of the Jaguaribe, bathing the municipalities of Alto Santo, Jaguaribara and Jaguaretama. It has an extension of 325 km², being completed in 2003 and has a storage capacity of 6.7 million m³.

The Piranhas-Açu River (map 3) , its spatiality and extension helps to understand the importance for the municipalities that accompany the hydrographic basin of this river. With its drainage area and its tributary rivers, highlighting all its course until its mouth, the main tributaries of the river-Piranhas-Açu are concentrated in the state of Paraiba (map 3) inserted totally in the northeastern semi-arid region and has its source in the municipality of Bonito from Santa Fé, in the State of Paraíba, following its natural course through the State of Rio Grande do Norte until it flows into the Atlantic Ocean, on the Potiguar coast.

[9] Network of reservoirs in the Northeast the largest on planet Earth, article by Manoel Bomfim Ribeiro. Available at: <https://www.ecodebate.com.br/2010/03/28/rede-de-acudes-do-nordeste-a-maior-do-planeta terra-artigo-de-manoel-bomfim-ribeiro /> consulted on 19 February 2020.

The Piranhas – Açú was perpetuated by the Curema-Mãe d´água dams and by the Armando Ribeiro Gonsalves dam, which became essential for supplying the municipalities in Rio Grande do Norte (MMA, 2006).

According to the RHANO (2006) notebook, the Piranhas-Açu is the main river of the Piranhas-Açu hydrographic sub-basin that is part of subdivision 2 of the Eastern Northeast Atlantic Hydrographic Region, and this sub-basin forms a drainage network of 43. 681, 50 km², with 26,183 km² comprising 60% of the state of Paraíba, e17. 498, 50 km² equivalent to 40% of the state of Rio Grande do Norte. It also supplies 147 municipalities, of which 102 are from Paraíba and 45 from Rio Grande do Norte. Its course is perpetuated by the Engenheiro Armando Ribeiro Gonsalves dam and the Curema-Mâe d´água reservoir system.

According to ANA (2012), the Engenheiro Armando Ribeiro Gonsalves dam was inaugurated in 1983 and is located on the bed of the Piranhas-Açu River, between the municipalities of Assú, Itajá and São Rafael. Its storage capacity is 2.4 million/m³, which makes it the largest water reservoir in Rio Grande do Norte.

Armando Ribeiro is responsible for supplying 20 urban centers located in Rio Grande do Norte, including outside the Piranhas-Açu river basin, as is the case in Mossoró. The benefited population is approximately 350,000 inhabitants (ANA, 2015).

The Curema-Mãe d´água reservoir system is formed by the junction of the Curema and Mãe d´água reservoirs, and the interconnection of the waters of the two reservoirs. The Curema reservoir releases water vessels to perpetuate the Piancó River (MMA, 2006) which flows into the Piranhas River, while water from the Mãe d´água reservoir perpetuates the Águia River, which is a tributary of the Piancó and Piranhas rivers. In some stretches it is necessary to use electric pumps, as the dams are in lower areas than the rivers. These perennial rivers are tributaries of the Piranhas-Açu River, located in the municipality of Piancó, about 400 km from João Pessoa. In the state of Paraíba, the Curema-Mãe d´água system was inaugurated in 1942, with a storage capacity of 1.35 million.

Also based on ANA (2016), the Curema reservoir and the Piancó and Piranhas rivers are responsible for supplying 30 urban centers located in the municipalities of Paraíba and Rio Grande do Norte. The urban population of this area alone is more than 350 thousand inhabitants, who depend on the Curema reservoir for supply. These water bodies also meet the demands associated with diffuse irrigation, aquaculture in excavated ponds and, to a lesser extent, industry.

The Capibaribe River (Map 3) rises in the Serra de Jacaré, on the border of the municipalities of Jatúaba and Poção, bathing 42 municipalities in Pernambuco, traveling 270 km to its mouth in the Atlantic Ocean, in the city of Recife. The intermittent system of the Capibaribe river sub-basin covers 7,454.88 km² and, in the lower course, crosses the historic center of Recife, a stretch perpetuated by the Carpina, Goitá and Tapacurá reservoirs[10].

The Carpina dam has a total storage capacity of 270 million/m³ and its main purpose was to contain flooding in the Capibaribe River, which mainly affected the city of Recife. Subsequently, it began to supply municipalities in its surroundings.

The Capibaribe River has its course within the state of Pernambuco and particularly in the city of Recife, covering the entire historic center of the city until it reaches its mouth in the Atlantic Ocean at the port of Recife.

The Padre Cicero public weir, commonly known as Castanhão, is a large-scale project, occupying an area of 325 km² in three municipalities (Alto Santo, Jaguaribe and Jaguaretama). The stored water flooded the city of Jaguaribe, which was transferred to another location, preserving its original historical and structural features. It is an interannual multiple-use reservoir, considered strategic with connection to other basins, being able to supply other places in the state of Ceará that lack water resources.[11].

[10] Joaquim Nabuco Foundation, Recife. Available in: < http://basilio.fundaj.gov.br/pesquisaescolar>. / Accessed on: January 6, 2020.
[11] Castanhão. Available at: <https://www.dnocs.gov.br/barragens/castanhao/castanhao.html/> consulted on January 25, 2020.

According to DNOCS (2015), the construction of these reservoirs was a paradigm shift for the Northeast, showing that it is possible to live with the drought in the semiarid with dignity. It changed the socioeconomic situation of the surrounding region, whether for urban consumption, for agricultural irrigation (40,000 hectares) or for fish farming. Castanhão (Photo 1), for example, supplies the metropolitan region of Recife, adding up to 12 municipalities that depend on its waters, making it a strategic tool for coping with the drought in the state of Ceará.

Photo 1 - Castanhão Weir. Ceará-Brazil- 2007

Source: Photo Claudio Lima (Panoramio2010)

In this way, the economic and social development project advances the limits of the Jaguaribe valley, being transformed into a pole of scope that goes beyond state borders. In this sense, it is clear that despite the water scarcity in the Northeast, with more public investments, the economic potential, especially in irrigated fruit and fish farming, contributes to favoring the development of the Jaguaribe Valley region.

Final considerations

By expanding possibilities of access to water, the perennialization of rivers has been strategically more effective both in human supply and in agricultural and livestock irrigation projects.

An alternative for the northeastern hinterland was put into practice with the dams and, although there are improvements to be made, they are being put forward with greater effectiveness to combat drought. However, it is necessary to expand public investments in order to increase the supply of water to the population living in the region, despite climatic peculiarities (low rainfall and high evaporation) and incipient hydrogeological capacity. It is the most inhabited semi-arid region in the world, an aspect that increases the need for storage strategies made possible by the construction of weirs/dams/reservoirs to accumulate water in the rainy season (spring-summer). These works lead to the perpetuation of rivers and changes in the landscape, which at specific points changes from ocher gray to olive green.

In certain places where there are no water reservoirs, or where they are dry, the water tank operation takes place, a policy to combat drought promoted by the Federal Government, operated by the Army and which collects water from public dams.

In this way, the dams are of fundamental importance in regulating the flows of the Jaguaribe, Piranhas Açu and Capibaribe rivers, where this practice of perpetuating the river ends up keeping the river with a volume of water sufficient to supply cities that suffer from water scarcity. Thus, the importance of perennialization cannot be denied, as long as it is conditioned to the conservation of the fauna and flora around these rivers.

In this conception, the constructions of these dams need to accompany the conservation and preservation mainly of the riparian forest on the banks of these rivers that contribute to the supply of water in periods of drought. The predominance of social impacts with the flooding of cities and villages is highlighted in the work, understanding that the bodies responsible for the construction of the dams must provide the necessary support in the removal of people to other places. In

the same way, the compensation of owners who have their properties flooded must also be made respecting legal mechanisms, without harming the rights of both parties.

Therefore, in view of the above, it is understood that the investigation meets the purposes established in the objective of analyzing the artificial perennialization of rivers through the construction of water reservoirs. These human works alter the natural dynamics of water systems, generating anthropic hydrographic basins. It is hoped that the study will motivate further research on the topic addressed.

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Author 2: Elaboration, bibliographic research, final analysis of the results and text review
Author 3: Supervision, selection of materials, suggestions and contributions of readings and research guidance